5.3 GEOLOGIC HAZARDS AND RESOURCES

This section of the application presents information on the geologic hazards and resources of the area surrounding the MPP site, in accordance with CEC requirements. The geologic and tectonic setting of the region and the project area are described, followed by an evaluation of geologic hazards including surface fault-rupture, strong seismic ground shaking, liquefaction, seismic settlement, flooding, slope stability, collapsible and expansive soils, and ground subsidence. Potential environmental impacts of the proposed project on the geologic resources at the MPP site are addressed, as are potential mitigation measures.

The final portion of this section describes LORS relevant to geologic impacts of the MPP and provides contacts in respective regulatory agencies. Required permits are also discussed.

5.3.1 Affected Environment

5.3.1.1 <u>Regional Geologic Setting</u>

The MPP site is located on the eastern end of the San Fernando Basin in the COB (Figure 5.3-1). The San Fernando Basin is part of the geologically complex and seismically active Transverse Ranges geomorphic province of Southern California. The Transverse Ranges geomorphic province is characterized by east-west trending mountain ranges and intervening valleys and is one of California's most seismically active regions.

The topographic pattern evident in this province results from active faulting that is driven by movement at the boundary between the North American and the Pacific crustal plates. These tectonic plates are passing each other horizontally (in a right-lateral sense) along the northwest-trending San Andreas fault system. Due to a westward bend in the San Andreas fault system, this movement of the tectonic plates results in north-south crustal compression across numerous east-west trending folds and faults.

5.3.1.2 <u>Site Geologic Conditions</u>

The ground surface elevation at the MPP site is about 560 feet above mean sea level (MSL), and the ground surface descends uniformly down to the southeast at a grade of about 0.5 percent.

As shown on Figure 5.3-1, the MPP site is located within the eastern portion of the San Fernando Valley, which is situated between the Verdugo Mountains to the north and the Santa Monica Mountains to the south. The San Fernando Valley is underlain by thick deposits of unconsolidated sediments, which were deposited mostly in a marine environment upon granitic and metamorphic basement rock. The surficial sediments in the area of the MPP site were mapped by Dibblee (1991) as Holocene age (less than 11,000 years ago) unconsolidated alluvial deposits consisting of clay, sand, and gravel. Recent borings at the MPP site by URS (2001) indicate that subsurface materials within the upper 100 feet below ground surface (bgs) generally consist of medium dense to very dense sands and silty sands. Layers of sandy silts, clays, and clayey sands were occasionally encountered.

5.3.1.3 Groundwater

The MPP site is located near the eastern margin of a groundwater basin designated the San Fernando Basin (Watermaster, 1999). The depth to a regional groundwater table beneath the MPP site is estimated to be approximately 90 feet bgs (Watermaster, 1999) and was encountered at a depth of about 97 feet below grade during the recent field investigation in February, 2001 (URS, 2001).

The San Fernando Basin is used by water purveyors for extraction of groundwater for public drinking water supply and for industrial purposes. The COB operates two active pumping wells in the vicinity of the MPP site (Watermaster, 1999). These water wells produced approximately 1,384 acre feet of water in 1998 (Watermaster, 1999).

Groundwater will not be extracted at the MPP site as part of the project. The impacts of the proposed development to the existing site groundwater conditions are anticipated to be minimal. In particular, the following are noted:

- The proposed development would not create new or increased subsurface water flow.

- The proposed MPP facilities or the foundations would not extend down to the groundwater table. Therefore, the proposed development would not interfere with groundwater flow or flow direction.

- The MPP would not result in demonstrable (i.e., at least one percent) reduction of groundwater recharge capacity. This is primarily because the MPP site is not an area of significant groundwater recharge. In addition, the scope of the proposed development would not impede recharge to areas further downgradient.

- The MPP should have no impact on the ability of a water purveyor to use the earth materials beneath the project area for public water supplies.

- The MPP would not increase the impervious area on the site, and thus would not decrease percolation.

- The proposed development would not involve emissions or contamination that would negatively affect groundwater quality. No mitigative measures relative to groundwater quality are required assuming standard care is taken during construction to control leaks, etc., from construction equipment.

5.3.1.4 Seismicity

Southern California is a seismically active region that can be expected to experience strong seismic shaking from future earthquakes generated by active faults. Earthquakes that will produce strong shaking at the MPP site may occur on mapped active or potentially active faults in the region, or on faults with little or no surface expression. Figure 5.3-2 depicts the approximate location of the MPP site in relation to known active, sufficiently active, and well-defined fault traces. Figure 5.3-2 also shows the approximate locations of historic earthquakes (up to 1998) with a magnitude 3.5 or greater that have occurred in the region.

5.3.1.5 Significant Seismic Sources

Figure 5.3-1 shows the locations of mapped and inferred faults that have been active in the late Quaternary in the vicinity of the MPP site. Based on the known activity of faults in the region and on the recorded seismicity (Figure 5.3-2), the MPP site is likely to experience strong ground shaking from future earthquakes. Of the many potential seismic sources known to exist in the region, those considered most significant to the seismic exposure of the project site are summarized in Table 5.3-1. Included on Table 5.3-1 is the nearest distance to the MPP site and the estimated maximum magnitude earthquake.

Further discussions of the known/assumed characteristics of the seismic sources considered potentially significant to the MPP site are presented in the following sections.

5.3.1.5.1 Verdugo-Eagle Rock Fault System. The Verdugo-Eagle Rock fault system includes the Verdugo, Eagle Rock, and San Rafael faults, with a total length of about 29 km (18 miles). Due in part to the relatively short length of this fault system, it was considered as rupturing together rather than in individual segments.

The Verdugo fault trends northward along the west flank of the Verdugo Mountains and separates a Precambrian-age basement complex on the east from alluvial and sedimentary Tertiary strata on the west. The Verdugo fault consists of multiple strands in a zone of about 0.5 km to 1 km in width (0.75 to 1.5 miles), as evidenced by southwest-facing scarps in alluvium in the Burbank area (Weber et al., 1980; Ziony and Yerkes, 1985). The Verdugo fault apparently dips 45 to 60 degrees to the northeast and forms groundwater cascades in the alluvium north of the terminus of the Verdugo Mountains. Southeast of the Verdugo

TABLE 5.3-1

LISTING OF FAULTS CONSIDERED TO BE SIGNIFICANT SEISMIC SOURCES FOR THE MPP SITE

Fault/Fault System Name	Displacement Style	Approximate Closest Distance To Site (km)	Approximate Closest Distance To Site (miles)	Estimated Maximum Magnitude Earthquake
Verdugo-Eagle Rock System	Reverse	2	1.2	6.7
Santa Monica Mountains System	Oblique/Thrust	7	4	7.2
Sierra Madre System	Reverse	9	5	7.1
Northridge Hills	Reverse	13	8	6.9
Puente Hills/Peralta Hills System	Thrust	13	8	6.5
Compton-Los Alamitos-Pelican Hill	Thrust/Oblique	14	9	6.8
San Gabriel	Strike Slip	15	9	7.0
Newport-Inglewood	Strike Slip	17	11	6.9
Santa Susana	Oblique	19	12	6.7
Elysian Park Blind Thrust	Thrust	21	13	6.7
Oakridge	Thrust	22	14	6.9
Whittier – Elsinore System	Oblique	33	21	6.8
Palos Verdes System	Oblique/Strike Slip	35	22	7.1
San Andreas System	Strike Slip	45	28	8.0

Note: Maximum earthquake magnitude based on estimated rupture length, estimated seismogenic depth, estimated fault plane dip, and an empirical relationship between fault rupture area and earthquake magnitude by Wells and Coppersmith (1994).

Mountains, the Verdugo fault becomes less well defined and its dip decreases as it trends through Verdugo Wash, where it apparently connects with the Eagle Rock fault. Groundwater cascades and surface scarps are evidence of Quaternary activity along the fault (Weber et al., 1980).

The Eagle Rock fault appears to consist of a single strand of approximately 5 km (3 miles) in length. The Eagle Rock fault appears to be a distinct segment situated between the Verdugo fault to the northwest and the San Rafael fault to the southeast. Ziony and Jones (1989) show the Eagle Rock fault as Late Quaternary based on offset stratigraphy of that age and fault physiography.

The San Rafael fault, with a length of about 6 km (4 miles), is a steeply dipping fault with an unresolved type of offset (Ziony and Yerkes, 1985). The San Rafael fault is not known to be structurally connected to - but rather forms the southern end of - the Verdugo, Eagle Rock, and San Rafael fault system. The San Rafael fault separates basement rock on the east from conglomerate-breccia of the Topanga Formation on the west. To the north, the San Rafael fault apparently dies out as a series of disjointed strands (Weber et al., 1980). To the south, the San Rafael fault is expressed as low areas and lineaments across terrace deposits. These apparent fault-related features suggest Late Quaternary age activity.

5.3.1.5.2 Elysian Park Thrust. The northwest trending Elysian Park anticlinorium is interpreted to be an active fault propagation fold linked to contractional deformation above the Elysian Park "blind" thrust fault (i.e., a low-angle reverse fault with no surface exposure). The Elysian Park thrust was considered by Davis et al. (1989) and Hauksson and Jones (1989) to be the source of the 1988 Whittier Narrows earthquake. Active seismicity and evidence of Quaternary deformation indicate that the Elysian Park blind thrust may be the source of future moderate magnitude earthquakes. In accordance with California Division of Mines and Geology (CDMG, 1996), the Elysian Park thrust is considered to be a 34 km (20 miles) long, 20-degree northeast dipping reverse fault.

5.3.1.5.3 Santa Monica Fault System. The Santa Monica fault system considered in this study includes the Raymond, Santa Monica, Hollywood, and Malibu Coast faults. These fault segments are modeled as steeply north-dipping faults with an oblique style. Based on Dolan et al. (1995), the fault system was considered to include a north-dipping, blind thrust source located beneath the Santa Monica Mountains.

The Raymond fault forms a prominent south facing scarp, trending west southwest from where it trends west from the Sierra Madre fault system, passing through the cities of Monrovia and San Marino. Studies by Crook et al. (1978; 1987) and Bryant (1978) have shown that the Raymond fault ruptured repeatedly in Holocene time (during the last 11,000 years), with an estimated recurrence interval of approximately 3,000 years. The Raymond fault is suspected to be the source of a July 1855 Magnitude (M) 6.0 earthquake (Yerkes, 1985). The December 3, 1988 M4.9 Pasadena earthquake, at a depth of about 16 km (10 miles), has been assigned to the Raymond fault. Studies indicated that slip occurred on a 70-degree north-dipping plane, and that the first motion was almost purely left lateral.

The Santa Monica fault is an east-west trending, northward-dipping, left lateral, reverse fault (Dolan and Sieh, 1992). It extends along the southern margin of the Santa Monica Mountains offshore into the northern portion of Santa Monica Bay. Based on trenching across the fault in the west Los Angeles area, Crook (1983) concluded that the most recent displacement of the Santa Monica fault is at least several thousand years old and most likely pre-Holocene. However, Hauksson and Saldivar (1986) reviewed the earthquakes recorded in Santa Monica Bay and suggested that the 1930, M5.2 Santa Monica earthquake occurred on the offshore western end of the Santa Monica fault. Ziony and Yerkes (1985) link the western portion of the Santa Monica fault with the Anacapa-Dume fault, located approximately 13 km (8 miles) off the Santa Monica coastline. However, studies by Hauksson and Saldivar (1986) suggest that the Santa Monica fault and the Anacapa-Dume fault are distinct fault segments, separated by an 8- to 10-km (5-to 6-mile) left step in the Santa Monica Bay area. Clark et al. (1984) have assigned a slip rate of 0.4 millimeters per year (mm/yr) for the Santa Monica fault, based on an offset marine wave-cut platform in Potrero Canyon. However, the slip rate for the Santa Monica fault is estimated by the CDMG (1996) to be approximately 1.0 mm/yr.

The Hollywood fault is located near the southern edge of the Santa Monica Mountains, north and parallel to the Santa Monica fault. The Hollywood fault can be traced for approximately 22 km (or 13 miles), and dips steeply to the north beneath the Santa Monica Mountains. Movement on the Hollywood fault has juxtaposed the granitic, metamorphic, and sedimentary rocks of the Santa Monica Mountains up and over the sedimentary deposits south of the mountains. Investigations in the Hollywood area (Converse Consultants, 1981) have revealed an apparent vertical displacement (north side up) of about 80 meters (270 feet), involving Pleistocene and Holocene alluvium. Although considered sufficiently active, no significant historic seismicity has been associated with the Hollywood fault.

The existence of a blind thrust beneath the Santa Monica Mountains was modeled by Dolan et al. (1995). This thrust fault is postulated to dip shallowly, approximately 20 degrees, to the north beneath the Santa Monica Mountains (Dolan et al., 1995). Its depth was taken to be from about 14 to 20 km (8.5 to 12.5 miles) (Dolan et al., 1995).

5.3.1.5.4 Sierra Madre Fault System. The Sierra Madre fault system forms a prominent east-west structural zone along the south side of the San Gabriel Mountains and consists of a complex system of northward-dipping (12 to 70 degrees), left lateral-reverse faults along which the mountains have been uplifted. Crook et al. (1987) indicates that this more-than-80-km–long (50 miles) fault system tends to rupture in discrete structural segments during earthquakes. Based on the work of Crook et al. (1987) and Clark et al. (1984) regarding recent activity and slip rates along the fault system, the Sierra Madre fault system can be subdivided into several segments. From west to east, the segments (and their approximate lengths) include the Mission Hills segment: 7 km (4.5 miles); the San Fernando segment: 19 km (12 miles); the Dunsmore segment: 17 km (10.5 miles); the Sierra Madre segment: 14 km (8.5 miles); the Duarte segment: 20 km (12.5 miles); the Claremont segment: 10 km (6 miles); and the Cucamonga segment: 22 km (14 miles).

The San Fernando fault ruptured in 1971, causing the moment magnitude (M_W) 6.6 San Fernando earthquake. The zone of surface rupture associated with this earthquake extended discontinuously for approximately 14 km (9 miles) with a maximum measured vertical displacement across the entire fault zone of about 2.4 m (7.9 feet) with the north side up. Although no surface rupture occurred, the 1991 Sierra Madre earthquake (M_W 5.6) has been attributed to the Sierra Madre segment. There are no records of moderate to large historic earthquakes occurring on the Dunsmore segment. Based on the work by Clark et al. (1984), a slip rate of 3 mm/yr is assumed for all four segments.

The Mission Hills fault trends generally east-west and is located near the northern margin of the San Fernando Valley. Based on Shields (1978), Ziony and Yerkes (1985) presumed the fault to be a single strand with an 80-degree northerly dip near the surface and a 45-degree northerly dip at depth. The sense of slip is presumed to be reverse. The fault is considered active based on the juxtaposition of bedrock against young-appearing soils in exploration trenches (Kowalwesky, 1978), but its slip rate is unknown. Although the Mission Hills fault is presumed to represent the western end of the Sierra Madre fault zone, the Mission Hills are not as high as the San Gabriel Mountains. Therefore, the slip rate of the Mission Hills fault is assumed to be lower than the rest of the Sierra Madre fault zone.

5.3.1.5.5 Northridge Hills Fault. The Northridge Hills fault is a reverse fault that trends southeasterly a total of about 23 km (14 miles) across the San Fernando Valley, along the south side of the Northridge Hills. The Northridge Hills fault forms a distinct, though discontinuous, topographic feature along its mapped length and consists of several en echelon strands in a zone of about 0.6 km (0.4 miles) in width (Ziony and Yerkes, 1985). Late Quaternary displacement along the Northridge Hills fault may be considerable, and several aftershocks of the 1971 San Fernando earthquake are believed to be closely associated with the fault (Ziony and Yerkes, 1985).

5.3.1.5.6 Puente Hills/Peralta Hills System. Recent work by Shaw and Shearer (1999) links geologic structural modeling with relocated earthquakes to show that the 1987 Whittier Narrows earthquake likely occurred on the Santa Fe Springs portion of the Puente Hills thrust. As reported by Shaw and Shearer (1999), the Puente Hills thrust is a northwest trending, north dipping blind thrust system that includes from west to east the Los Angeles segment, the Santa Fe Springs segment, and the Coyote Hills segment.

The Peralta Hills fault is a north-dipping thrust fault that has juxtaposed Miocene sedimentary rock against Pleistocene terrace deposits, along the south side of the Peralta Hills. The Peralta Hills fault is mapped in surface exposures as far west as the Costa Mesa Freeway (Interstate 55) in Orange County. Based on the observation that the north-dipping Peralta Hills thrust is approximately on-trend with the fault segments suggested by Shaw and Shearer (1999), the Peralta Hills thrust is considered in this study to be part of the overall Puente Hills thrust system.

5.3.1.5.7 Compton-Los Alamitos-Pelican Hill. Although not known to be related, the trends of the Pelican Hill and Los Alamitos faults roughly align. The inferred (buried) trace of the Compton fault described by Wright (1991) also roughly aligns with the Los Alamitos and Pelican Hill faults. For this reason, these three faults are treated in this study as a through-going system.

As reported by Ziony and Yerkes (1985), the Pelican Hill fault consists of several strands, strikes northwesterly, and dips about 75 degrees west near the surface but about 45 degrees west at depth. Based on offset stratigraphy, the fault is believed to be late Quaternary in age, and the sense of offset along the fault is reported as normal or normal right oblique. Scattered small earthquakes have been located west of its trace, and it is classified as potentially active according to Ziony and Jones (1989). A slip rate of about 0.5 mm/yr is estimated for the fault, based on a review of relative block motions and comparisons with other faults such as the Offshore Zone of Deformation and the Newport-Inglewood fault.

As mapped by the California Department of Water Resources (1961), the Los Alamitos fault is a northwest-trending concealed fault, about 10 km (6 miles) long. Cross sections based on water well data suggest that the fault offsets aquifers within the Pleistocene-age San Pedro Formation, but not the younger (late Pleistocene-age) Lakewood Formation. However, based on the location of earthquake epicenters along its trend (Hauksson, 1987), the fault is presumed to be at least potentially active. The slip rate on the fault is unknown, but estimated to be about 0.5 mm/yr, based on a review of relative block motions and comparisons with other faults such as the Offshore Zone of Deformation and the Newport-Inglewood fault.

The existence and location of the Compton fault is based on a compilation of oil field data and interpretations by Wright (1991). Based on his information, the Compton fault is assumed to be about 28 km (17 miles) long, and dip about 60 degrees west. In this study, the assumption that the Compton fault is potentially active is based on its interpreted association with the Los Alamitos fault, which is located approximately along trend to the southeast and is suspected to be a potentially active structure. A slip rate of about 0.5 mm/yr is assumed for the fault, based on the assumption of its association with the Pelican Hill and Los Alamitos faults.

5.3.1.5.8 San Gabriel. The San Gabriel fault may have been an ancient segment of the San Andreas fault that had large lateral displacements during later Tertiary time. Since early Pleistocene time, the San Gabriel fault appears to have been bypassed by the current traces of the San Andreas fault, and activity on the San Gabriel fault has subsequently diminished. However, Bull et al. (1979) show evidence of Quaternary displacement on the San Gabriel fault. Additional evidence of some Quaternary and possible Holocene displacements has been reported along the San Gabriel fault trace in the Saugus/Castaic area (Cotton, 1986).

5.3.1.5.9 Newport-Inglewood. The Newport-Inglewood fault zone is an active right-lateral wrench fault system consisting of a series of en echelon fault segments and anticlinal folds that are believed to be the expression of a deep seated fault within the basement rock

(Barrows, 1974; Harding, 1973; Yeats, 1973). The fault zone is visible on the surface as a series of northwest trending elongated hills, including Signal Hill and Dominguez Hills, extending from Newport Beach to Beverly Hills.

From Beverly Hills to Newport Beach, the total fault length is about 73 km (45 miles). Based on the character of the fault's trace and the occurrence of the 1933 Long Beach (M6.3) and the 1920 Inglewood (M4.9) earthquakes, the fault was considered as consisting of two rupture segments: the Inglewood segment and the Long Beach segment.

Up to approximately 1,800 m (6,000 feet) of right-lateral displacement has accumulated on the zone since mid-Pliocene time, with a maximum displacement of 3,000 m (10,000 feet) since late-Miocene time (Woodward-Clyde Consultants, 1979). A highly variable and significantly lesser degree of vertical displacement, generally associated with local folding, also occurred during that same time span. Based on that data, the average long-term horizontal slip rate appears to have been about 0.5 mm/yr.

5.3.1.5.10 Santa Susana. The Santa Susana fault is a range-front fault that extends along the western portion of the Santa Susana Mountains for a distance of about 38 km (23.5 miles). Two segments are identified: a western segment (about 27 km [17 miles] in length) and an eastern segment (about 11 km [7 miles] in length).

According to Ziony et al. (1974), the eastern portion of the Santa Susana fault has experienced Pliocene displacement. Surface displacements were mapped along its trace following the 1971 M6.4 San Fernando earthquake. However, there is some question as to whether these surface features represented surface fault rupture, partly because no movement was recorded on the fault plane where it is penetrated by numerous wells in the Aliso Canyon gas storage facility. A slip rate of 3.0 mm/yr is assigned to the western segment of this fault, based on regional balancing of slip rates and deformation rates measured by GPS, and published research (Huftile, 1995). In this study, it is assumed that the slip rate decreases to 0.5 mm/yr at the eastern end of the fault. Ziony and Yerkes (1985) associate scattered small earthquakes with the Santa Susana fault, including a M_W 4.6 event in 1976.

5.3.1.5.11 Oakridge - Northridge Blind Thrust. The Oakridge fault system is considered to be comprised of the onshore portion of the Oakridge fault, and the Northridge blind thrust, a previously unrecognized fault beneath the San Fernando Valley and the Santa Susana Mountains that produced the January 17, 1994 Northridge earthquake. The onshore Oakridge fault extends approximately east-west for a total length of about 53 km (33 miles). The Northridge blind thrust is estimated to extend farther east of the Oakridge fault, for approximately 27 km (17 miles).

During the Northridge earthquake, the San Fernando area moved up and to the north in a thrusting motion. The source fault is described as "blind" because it does not appear to reach the ground surface. It has been hypothesized that the "Northridge blind thrust" is a subsurface extension of the Oakridge fault. From seismological and geodetic evidence, the Northridge Blind Thrust dips approximately 30 to 40 degrees to the south, and trends roughly east-west (Southern California Earthquake Council [SCEC] and Caltech Seismological Laboratory, 1994). The zone of aftershocks defines a fault plane that is approximately 25 to 30 km (15 to 18 miles) in length, extending to a depth of approximately 20 km (12 miles). The San Fernando Valley is located above the inclined fault plane.

5.3.1.5.12 <u>Whittier-Elsinore Fault</u>. The Whittier fault has been mapped along the south side of the Puente Hills from its intersection with the Elsinore fault near Corona, northwesterly to the City of Whittier. Slip along the fault is predominantly right lateral, with some reverse slip on a steeply north-dipping fault plane. The largest historical earthquake on this fault occurred in 1976 and had a magnitude of 4.2. Based on preliminary paleoseismic studies, the best estimate of the slip rate of the Whittier fault is taken to be approximately 2.5 mm/yr (Dolan et al., 1995).

5.3.1.5.13 <u>Palos Verdes Fault</u>. The Palos Verdes fault forms the abrupt northern front of the Palos Verdes Hills. The onshore portion of the fault has a mapped length of about 14 km (9 miles). In addition, the fault has been mapped northward under Santa Monica Bay to the Redondo Canyon fault, and may extend farther north to the Anacapa-Dume/Santa Monica faults. Southeast of the Palos Verdes peninsula, the fault has been mapped offshore to where it bifurcates around Lasuen sea knoll, which is located offshore of San Clemente (Nardin and Henyey, 1978).

From Santa Monica Bay to Lasuen sea knoll, the total length of the Palos Verdes fault system is estimated to be approximately 115 km (71 miles). Based on the studies performed at Los Angeles Harbor, the fault's style appears to be dominantly right lateral southeast of the harbor. North of Los Angeles Harbor, the fault's style appears to be oblique. The length of the segment north of the Los Angeles Harbor is about 49 km (31 miles), and the length of the segment south of the Los Angeles Harbor is about 66 km (41 miles).

Movement on the Palos Verdes fault, as expressed in the onshore segment, appears to be reverse, right-lateral with at least 1,800 m (6,000 feet) of vertical displacement (down on the northeast) since late Miocene time, and 60 m (200 feet) to 90 m (300 feet) of vertical displacement since the early Pleistocene period (Woodward-Clyde Consultants, 1982; Zielbauer et al., 1962; Ziony and Yerkes, 1985).

Although no evidence of surface rupture is currently known for the onshore segment, there are several lines of evidence that suggest the continuing uplift and thus the continuing activity of the Palos Verdes fault. The fault is considered active because of: (1) the large, youthful topographic expression of the uplifted Palos Verdes Hills; (2) geodetic data that suggest continuing uplift of the Palos Verdes Hills; (3) the apparent association of the fault with recent seismic activity up to M3.9 (Teng and Henyey, 1975); and, (4) the apparent offsets of the sea floor and late Pleistocene and Holocene sediments based on interpretation of data from offshore seismic reflection surveys. Based on tectonic modeling studies and data from offshore studies in the Los Angeles Harbor, the Palos Verdes fault is presumed to have a slip rate ranging from about 1.0 to 4.0 mm/yr, with a preferred value of 3.0 mm/yr.

5.3.1.5.14 San Andreas Fault. The San Andreas Fault is the main active crustal discontinuity that separates the northwest moving Pacific plate from the North American plate. This right lateral strike slip fault extends from the Gulf of California northward along the western edge of California, then extends offshore north of San Francisco. Historically, the San Andreas fault has produced earthquakes up to about magnitude 8.

As discussed by the U.S. Geological Survey Working Group on Earthquake Probabilities (1988), the fault can be divided into several discrete segments along its length, based on differing seismic characteristics. Northwest from the Coachella Valley, the following segments (and approximate segment lengths) of the San Andreas fault have been identified: the Coachella segment: 200 km (124 miles); the San Bernardino Mountains segment: 100 km (62 miles); the Mojave segment: 100 km (62 miles); the Carrizo segment: 145 km (90 miles); and the Cholame segment 55 km (34 miles). In future earthquakes, these segments may rupture separately or together, as occurred in the 1857 Fort Tejon earthquake (estimated M7.9) when the Cholame, Carrizo, and Mojave segments ruptured. That portion of the fault has also been referred to as the south-central segment, and is the closest portion of the fault to the Los Angeles region.

Work by Sieh et al. (1989) and Grant and Sieh (1994) provides evidence of large earthquakes occurring, on the average, about every 140 to 160 years on the south-central segment of the fault. Based on the U.S. Geological Survey Working Group on Earthquake Probabilities (1988), a slip rate of about 34 mm/yr is assumed for this portion of the fault.

The nearest portion of this right-lateral strike slip fault is located approximately 45 km (28 miles) to the northeast of the MPP site. This portion of the fault ruptured in 1857 in the Fort Tejon earthquake.

5.3.1.6 Geologic and Seismic Hazards

Several types of potential geologic hazards known to be present in parts of California were evaluated for their potential impact on the proposed site structures. These include surface fault rupture, seismic shaking, liquefaction, seismically-induced settlement, flooding, landsliding, expansive soils, and ground subsidence. An evaluation of the potential impacts on the site from these potential geologic hazards is presented in the following sections.

5.3.1.6.1 Fault Rupture. Based on a review of the pertinent geologic literature, there are no known active faults on or immediately adjacent to the site. The MPP site is not within an Alquist-Priolo "Special Studies Zone"[1] and the COB Safety Element (Leighton and Associates, 1990) did not delineate active or potentially active faults at the site. Because there are no known active faults on or adjacent to the MPP site, the potential for tectonic fault rupture is considered negligible.

5.3.1.6.2 Seismic Ground Motion. The geologic hazard with the greatest potential to affect the MPP is strong seismic shaking from future earthquakes in the site region. Based on procedures outlined in the Uniform Building Code (International Conference of Building Officials, 1997) the peak ground acceleration at the MPP site is estimated to be about 0.52 g, which corresponds approximately to an average return period of 475 years. The potential for the MPP site to experience significant seismic ground motion is considered to be high.

5.3.1.6.3 Liquefaction Potential. Liquefaction is a phenomenon that causes water-saturated, cohesionless granular materials to change into a fluid-like state when subjected to powerful shaking associated with strong earthquakes. Liquefaction causes materials to lose their strength and their ability to support a load, and therefore liquefaction related ground failures is a significant seismic hazard to be evaluated. The susceptibility of a site to undergo liquefaction is a function of the type of sedimentary deposit, the density of cohesionless sediment, and the depth to groundwater. Saturated, cohesionless granular soil situated at depths less than 30 feet are generally regarded as the most susceptible to liquefaction (Tinsley et al., 1985).

The California Division of Mines and Geology Seismic Hazard Zones Map for the Burbank 7.5 minute quadrangle (1999) shows the area encompassing the MPP site as having a "potential for permanent displacements" resulting from liquefaction (Figure 5.3-3).

The above reference would seem to indicate that there is some likelihood of liquefaction at the MPP site. However, the liquefaction susceptibility maps noted above present a regional interpretation of liquefiable areas for general land use planning purposes. They present conservative interpretations of liquefaction susceptibility and have not been refined using site-specific geotechnical data. A site-specific study conducted in February, 2001 (URS, 2001) indicates that the subsurface materials encountered at the MPP site consist primarily of

[1] The "Alquist-Priolo Earthquake Fault Zoning Act" is a state law that regulates development projects near active faults to mitigate the hazard of surface fault rupture. The act requires that development permits for projects within an "Earthquake Fault Zone" (Special Studies Zone) be withheld until geologic investigations demonstrate that the sites are not threatened by surface displacement from future fault rupture.

medium dense to very dense granular materials with occasional finer-grained layers. Groundwater was encountered at a depth of about 97 feet below the existing ground surface. Based on the relatively high density of the subsurface materials and the lack of near-surface groundwater, it is concluded that the potential for liquefaction at the site is negligible. Other geologic hazards related to liquefaction, such as lateral spreading, are therefore also negligible.

5.3.1.6.4 <u>Seismic Settlements</u>. Loose to medium dense granular soils will tend to densify during the application of cyclic shear, typically resulting in settlements of the ground surface. The magnitude of earthquake-induced settlement is a function of the initial density of the materials, the level of ground shaking, and the thickness of the soil layers that densify. Earthquake-induced settlements can occur in materials under a range of moisture conditions from dry to saturated.

The materials at the MPP site are typically medium dense to very dense granular materials, with occasional finer-grained materials. These materials would not typically be susceptible to significant settlement from seismic shaking. Assuming a peak ground acceleration of 0.52g from a magnitude 7.5 earthquake, and following the procedure outlined by Tokimatsu and Seed (1987), a seismic settlement of less than ¼ inch was calculated. As a result, the hazard from seismic settlement is considered to be insignificant.

5.3.1.6.5 <u>Flooding</u>. Flood hazards evaluated for having the potential to impact the MPP site include storm-induced flooding and floods caused by earthquakes, such as due to earthquake-related dam failure. During the early history of Los Angeles County, the coastal lowlands, including the MPP site, were vulnerable to flooding from intense winter storms. However, since the construction of the U.S. Army Corps of Engineers' flood control system, which consists of an extensive system of levees, concrete-lined channels, dams, and debris basins, the hazards due to storm induced flooding have been substantially reduced. The Flood and Inundation Hazard Map from the Los Angeles County Safety Element (Los Angeles County, 1990) indicates the site is not designated as being within either a 100-year or 500-year flood area. The Federal Emergency Management Agency (FEMA) states that this area is either in Zone C, meaning the site has minimal flooding potential, or else has potential flooding areas (Zone A) sufficiently channelized (FEMA, 1999). Based on this, the potential at the site for flooding from storms is considered low.

Earthquake-induced flooding could also be the result of catastrophic dam failure from seismic shaking or surface fault rupture. As shown on Figure 5.3-4, the MPP site is located within the flood inundation area for the Hansen Dam. Because Hansen Dam is a flood control facility, which impounds water only during periods of infrequent high seasonal precipitation, the probability of flooding due to coincident seismically-induced dam failure is considered to be low.

5.3.1.6.6 <u>Debris Flows</u>. The MPP site is situated in a developed area. The surrounding areas do not have steep slopes. As such, the potential for the MPP site to receive debris flows is considered low.

5.3.1.6.7 <u>Tsunamis</u>. Tsunamis are produced by large-scale sudden disturbances of the sea floor, such as from underwater landslides or from earthquakes. Tsunami waves interact with the shallow sea floor topography upon approaching a land mass, resulting in an increase in wave height and a destructive wave surge into low-lying coastal areas. With the MPP site being approximately 15 miles inland from the coastline and at an elevation of about 560 feet above MSL, the site is well outside of the tsunami inundation area designated in the Los Angeles County Safety Element (1990). As such, there is no potential for damage from a tsunami at the site.

5.3.1.6.8 <u>Slope Stability</u>. The MPP site area is on a flat alluvial plane, and therefore not subject to slope instability. In addition, there are no slopes being created in the proposed project. As such, the slope stability hazard potential at the MPP site is negligible.

5.3.1.6.9 <u>Expansive Soils</u>. Expansive soils swell when they become wet and shrink when they dry out, resulting in the potential for cracked building foundations and, in some cases, structural distress of the buildings themselves. Typical expansive soil materials include highly plastic clays, elastic silts, and shale comprised of particular geologic components. However, the subsurface materials at the site consist almost entirely of granular materials (sands and silty sands), which are non-expansive in nature. As a result, the potential at the MPP site for expansive soils that would affect the proposed construction is considered very low.

5.3.1.6.10 <u>Ground Subsidence</u>. Ground subsidence is the sinking of the ground surface as a result of fluid withdrawal (e.g., petroleum or groundwater). There is no evidence of ground subsidence between 1971 and 1989 in the vicinity or that has affected the MPP site (Hodgkinson, et al., 1996). In addition, this area has not been recognized as having a major incidence of subsidence. It is concluded that the potential for ground subsidence at the MPP site is low.

5.3.2 Environmental Consequences

Natural resources occurring within the area include sand deposits and oil and gas resources. The following section discusses these resources in the vicinity of the MPP site.

5.3.2.1 Sand and Gravel Aggregate Resources

The MPP site is located in an area designated by the CDMG (1979) as a Mineral Resource Zone (MRZ) -2 Area. According to the CDMG (1979), MRZ-2 areas are defined as “Areas where adequate information indicates that significant mineral deposits are present, or where it is judged that high likelihood exists for their presence.” However, the MPP site is also noted by the CDMG (1979) as being located within “existing urbanized areas.” The MPP site is located in a commercial and/or industrial area, and is currently being used for a power generating facility. No mineral resources are known at the MPP site. Therefore, the MPP would not likely have an adverse impact on mineral resources in the state of California.

5.3.2.2 Oil and Gas Resources

The MPP site does not lie within an oil or gas field and there are no currently active oil and gas wells in the vicinity of the proposed project (Munger Map Book, 1999). Therefore, the MPP would not likely have an adverse impact on oil or gas resources in the state of California.

5.3.2.3 Mineral Resources

The MPP site is located in an area designated as a MRZ-2 area by the CDMG (1979). An MRZ-2 area is defined by the CDMG (1979) as “Areas where adequate information indicates that significant mineral deposits are present, or where it is judged that high likelihood exists for their presence.” However, the proposed project site is also noted by the CDMG (1979) as being located within “existing urbanized areas.” The MPP site is currently being used for a power generating facility and there are no known mineral resources at the site. Therefore, the proposed project would not likely have an adverse impact on mineral resources in the state of California.

5.3.2.4 Consequences to Natural Resources

Natural resources occurring within the region include sand and gravel as aggregate resources and oil and gas resources. All of these resources have been exploited, at least in a limited manner, in the vicinity of the MPP site. There are currently no significant sand and gravel mines in the area and, given the urban setting, there is little or no potential for new production in the area.

There are producing oil wells in the San Fernando Valley but there are no active wells in the vicinity (Munger, 1999) of the MPP site. The proposed construction within the plant site or along the ancillary pipelines will not impact existing or future oil or gas production in the area. No significant impacts on natural resources would occur as a result of project implementation.

5.3.2.5 Cumulative Impacts

A review of the existing site conditions and the proposed project development indicates that no cumulative impacts from geologic hazards or to geologic resources resulting from the MPP have been identified.

5.3.3 Mitigation Measures

As a means of cooperating with the CEC by establishing a conciliatory relationship and an open, efficient AFC process that allows the Commission to utilize its resources in the most efficient manner possible, the SCPPA expresses a willingness to employ the following mitigation measures:

GEO-1: At least 30 days (or a lesser number of days mutually agreed to by the Applicant and the Chief Building Official [CBO]) prior to the start of construction, the Applicant will submit to the Compliance Project Manager (CPM) for approval the name(s) and license number(s) of the certified engineering geologist(s) assigned to the project. The submittal will include a statement that the CPM's approval is needed. The CPM will approve or disapprove of the engineering geologist(s) and will notify the Applicant of its findings within 15 days of receipt of the submittal. If the engineering geologist(s) is subsequently replaced, the Applicant will submit for approval the name(s) and license number(s) of the newly assigned individual(s) to the CPM. The CPM will approve or disapprove of the engineering geologist(s) and will notify the Applicant of the findings within 15 days of receipt of the notice of personnel change.

GEO-2: The Applicant shall include in the application for a grading permit a report of the liquefaction analysis, and a summary of how the results of this analysis were incorporated into the project grading plan, for the COB's review and comment.

GEO-3: (1) Within 15 days after submittal of the application(s) for grading permit(s) to the CBO, the Applicant will submit a signed statement to the CPM stating that the Engineering Geology Report has been submitted to the CBO as a supplement to the plans and specifications and that the recommendations contained in the report are incorporated into the plans and specifications. (2) Within 90 days following completion of the final grading, the Applicant will submit copies of the Final Engineering Geology Report to the CBO, and to the CPM on request.

5.3.4 Other Mitigation

The following measures are proposed to mitigate any potentially significant geologic hazards to less than significant levels for the plant site. No unavoidable adverse impacts that cannot be mitigated have been identified for the MPP. These mitigation measures are more accurately described as project design features. They are presented in this report for clarity.

5.3.4.1 Surface Faulting Rupture

No active (Holocene) or potentially active (Quaternary) faults were found to cross the MPP site. As such, the potential impact from ground rupture is negligible and no mitigation measures are required.

5.3.4.2 Earthquake Ground Shaking

The power plant facilities will likely be subjected to moderate to strong earthquake motions in their lifetime. Thus, they will need to be designed and constructed at a minimum to the seismic design requirements for ground shaking specified in the current Uniform Building Code (International Conference of Building Officials, 1997) for Seismic Zone Four and the California Building Code (CBC) (California Building Standards Commission, 1998). Proper design and construction will reduce impacts from ground shaking to less than significant.

5.3.4.3 Flooding

Based on the setting of the MPP site, no specific mitigation measures are considered necessary against flooding.

5.3.4.4 Tsunamis

Based on the setting of the MPP site, no specific mitigation measures with respect to tsunami hazards are considered necessary.

5.3.4.5 Slope Stability

Based on the setting of the MPP site and the descriptions of the proposed construction, no specific mitigation measures with respect to slope stability are considered. Any temporary and permanent slopes associated with the project will be designed, constructed, and maintained in accordance with the requirements of the current Building Code adopted by the COB and the state of California.

5.3.4.6 Liquefaction

Based on the specific subsurface conditions encountered at the MPP site, the potential for liquefaction is negligible and no specific measures to mitigate liquefaction potential are considered necessary.

5.3.5 Applicable Laws, Ordinances, Regulations, and Standards

The proposed project will comply with applicable LORS pertaining to geological hazards and resources during construction and operations. Applicable LORS are discussed below and summarized in Table 5.3-2.

TABLE 5.3-2

LORS APPLICABLE TO GEOLOGIC HAZARDS AND RESOURCES

LORS	Applicability	Conformance (section)
Federal		
No federal LORS are applicable. (See also Section 3.12.)		
State		
Cal PRC §25523(a), Alquist-Priolo Special Study Zone	N/A	Section 5.3.5.2
California Building Code, Chapters 16 and 33	Codes address excavation, grading and earthwork construction, including construction applicable to earthquake safety and seismic activity hazards.	Sections 3.5, 5.3.5.3, Appendix G
Local		
1997 Uniform Building Code with Amendments by the COB Community Development Department	Codes address excavation, grading and earthwork construction, including construction applicable to earthquake safety and seismic activity hazards.	Sections 3.5, 5.3.5.3, Appendix G

5.3.5.1 Federal

No federal LORS are applicable.

5.3.5.2 State

California Public Resources Code Section 25523(a): 20 CCR Section 1752(b) and (c). No project components cross an Alquist-Priolo Special Study Zone (APSSZ). The MPP will not be subject to requirements for construction within the APSSZ.

<u>California Building Code 1998, Appendix Chapter 33</u>. This element sets forth rules and regulations to control excavation, grading and earthwork construction, including fills and embankments. It establishes basic policies to safeguard life, limb, property and public welfare by regulating grading on private property.

The geotechnical engineer and engineering geologist will certify the placement of fills and the adequacy of the site for structural improvements in accordance with the CBC, Appendix Chapter 33.

The geotechnical engineer will address Sections 3309 (Grading Permit Requirements), 3312 (Cuts), 3315 (Drainage and Terracing), 3316 (Erosion Control), 3317 (Grading Inspection), and 3318 (Completion of Work) of the CBC, Appendix Chapter 33. Additionally, the engineering geologist will present findings and conclusions pursuant to PRC, Section 25523(a) and 20 CCR, Section 1752(b) and (c).

<u>California Building Code 1998, Volume 2, Chapter 16</u>. This element sets forth rules and regulations that address potential seismic hazards.

5.3.5.3 <u>Local</u>

The MPP site is located in the COB and would be subject to the LORS for the COB. The administering agency for the above authority is the COB Building Division of the Community Development Department.

5.3.5.4 <u>Agencies and Agency Contacts</u>

Agencies with jurisdiction to issue applicable permits and/or enforce LORS related to geologic hazards and resources, and the appropriate contact person are shown in Table 5.3-3.

TABLE 5.3-3

INVOLVED AGENCIES AND AGENCY CONTACTS

Agency	Contact/Title	Telephone
California Division of Mines and Geology (CDMG) *	Jim Davis, State Geologist, Office of the State Geologist	(916) 445-1923
City of Burbank Community Development Department	Art Bashmakian, City Planner	(818) 238-5250
City of Burbank Community Development Department Building Division	Thomas Sloan, Plan Check	(818) 238-5220
City of Burbank Fire Department	Devin Burns, Hazardous Waste Specialist	(818) 238-5250

*Geological resources and hazards fall under the jurisdiction of the CDMG.

5.3.5.5 Applicable Permits

Grading permits will be issued by the COB based on a review of the grading plan and the Geotechnical Investigation Report.

5.3.4 References

Barrows, A.G. 1974. “A Review of the Geology and Earthquake History of the Newport-Inglewood Structural Zone, Southern California.” California Division of Mines and Geology Special Report 114. 115 p.

Bryant, W.A. 1978. “The Raymond Hill Fault, An Urban Geological Investigation.” *California Geology*. California Division of Mines and Geology. Vol. 31. No. 6. pp. 127-142. June.

Bull, W.B., C.M. Menges, and L.D. McFadden. 1979. “Stream Terraces of the San Gabriel Mountains, Southern California. Final Technical Report. South Front of the San Gabriel Mountains, Southern California.” U.S. Geological Survey Contract No. 4-08-0001-G-394.

California Building Standards Commission. 1998. “1998 California Building Code, Based on the 1997 UBC.”

California Department of Water Resources. 1961. “Planned Utilization of the Ground Water Basins of the Coastal Plain of Los Angeles County, Groundwater Geology.” Bulletin No. 104, Appendix A.181 p.

California Division of Mines and Geology. 1999. “Official Map of Seismic Hazard Zones, Burbank Quadrangle.” August 25.

1996. “Probabilistic Seismic Hazard Assessment for the State of California.” Open File Report 96-08.

1979. “Mineral Land Classification of the Greater Los Angeles Area”, Special Report No. 143.

Clark, M.M., K. Harms, J. Lienkaemper, D. Harwood, K. Lajoie, J. Matti, J. Perkins, J. Rymer, A. Sarna-Wojcicki, R. Sharp, J. Sims, J. Tinsley, and J. Ziony. 1984. “Preliminary Slip-Rate Table and Map of Late Quaternary Faults of California.” U.S. Geological Survey Open-File Report 84-106.

Converse Consultants. 1981. "Geotechnical Investigation Report for Southern California Rapid Transit District Metro Rail Project." Consultants Report. Vol. l.

Cotton, W.R. 1986. "Holocene Paleoseismology of the San Gabriel Fault, Saugus/Castaic Area, Los Angeles, California" In P. L. Ehlig (compiler*) Neotectonics and Faulting in Southern California*" Guidebook for 82nd Meeting, Geological Society of America, Cordilleran Section.

Crook, R., Jr. 1983. "Final Technical Report, Seismicity of the Santa Monica and Hollywood Faults Determined by Trenching." U.S. Geological Survey Contract No. 14-08-0001-10523.

Crook, R. Jr., C.R. Allen, B. Kamb, C.M. Payne, and R.J. Proctor. 1987. "Quaternary Geology and Seismicity Hazard of the Sierra Madre and Associated Faults, Western San Gabriel Mountains." in Recent Reverse Faulting in the Transverse Ranges, California. D.M. Morton and R.F. Yerkes, eds. U.S. Geological Survey Professional Paper 1339. pp. 27-63.

1978. "Quaternary Geologic and Seismic Hazard of the Sierra Madre and Associated Faults, Western San Gabriel Mountains, California." U.S. Geological Survey Contract No. 14-08-0001-15258.

Davis, T.L., J. Namson, and R.F. Yerkes. 1989. "A Cross Section of the Los Angeles Area: Seismically Active Fold and Thrust Belt, the 1987 Whittier Narrows Earthquake, and Earthquake Hazard." *Journal of Geophysical Research.* Vol. 94. pp. 9,644-9,664.

Dibblee, Thomas W., Jr. 1991. "Geologic Map of the Hollywood and Burbank (South ½) Quadrangles, Los Angeles County, California." Map Scale 1:24,000. Dibblee Geological Foundation Map #DF-30. The Dibblee Geologic Foundation, Santa Barbara, California. May.

Dolan, J. F. and K.E. Sieh. 1992. "Structural Style and Tectonic Geomorphology of the Northern Los Angeles Basin: Seismic Hazards and Kinematics of Recent Fault Movement." Proceedings of the 35th Annual Meeting of the Association of Engineering Geologists, Los Angeles, California.

Dolan, J. F., K.E. Sieh, T. K. Rockwell, R. S. Yeats, J. Shaw, J. Suppe, G. J. Huftile, and E. M. Gath. 1995. "Prospects for Larger or More Frequent Earthquakes in the Los Angeles Metropolitan Region." in *Science*. Vol. 267. pp. 199-205. January 13.

Federal Emergency Management Agency. 1999. "Flood Insurance Rate Map, Map Index." Community Panel Numbers 060137 0001-0112. Map revised May 4, 1999.

Grant, L.B. and K. Sieh. 1994. “Paleoseismic evidence of clustered earthquakes on the San Andreas fault in the Carrizo Plain, California.” *Journal of Geophysical Research.* Vol. 99, Number B4, 10 April, pp. 6,819-6,841.

Harding, T.P. 1973. “Newport-Inglewood Trend, California - An Example of Wrench Style Deformation.” *Bulletin of the American Association of Petroleum.*

Hauksson, E. 1987. “Seismotectonics of the Newport-Inglewood Fault Zone in the Los Angeles Basin.” *California Seismologic Society of America Bulletin.* Vol. 77. pp. 539-561.

Hauksson, E.H. and G.V. Saldivar. 1986. “The 1930 Santa Monica and the 1979 Malibu California Earthquakes.” *Bulletin of the Seismological Society of America.* Vol. 76. No. 6.

Hauksson, E.H., and Jones, L.M. 1989. “The 1987 Whittier Narrows Earthquake Sequence in Los Angeles, Southern California: Seismological and Tectonic Analysis.” *Journal of Geophysical Research.* Vol. 94. No. B7.

Huftile, G. 1995. Personal Communication (L. Grant) on Ventura Basin Structural Interpretations. Oregon State University.

International Conference of Building Officials. 1997. “Uniform Building Code.” Whittier, California.

Kowalwesky, D.B. 1978. “Indications of Holocene Activity Along Branches of the Mission Hills Fault West of Balboa Boulevard” in Geologic Guide and Engineering Geology Case Histories, Los Angeles Metropolitan Area. Association of Engineering Geologists, Los Angeles, California. Guidebook. pp. 53-63.

Leighton and Associates. 1990. “Technical Database for the Revision of the City of Burbank Safety Element.” Consultants report for the City of Burbank Planning Division. Project No. 2891058-01. September.

Los Angeles County. 1990. “Los Angeles County Safety Element.”

Munger Map Book. 1999. California – Alaska Oil and Gas Fields, Fortieth Edition.

Nardin, T.R. and T.L. Henyey. 1978. “Pleistocene-Pliocene Diastrophism of Santa Monica and San Pedro Shelves, California Continental Borderland.” *Bulletin of the American Association of Petroleum Geologists.* Vol. 62. No. 2. February.

Shaw, J.H., and Shearer, P.M. 1999. "An Elusive Blind Thrust Fault Beneath Metropolitan Los Angeles." in *Science*. vol. 283. pp. 1516–1518. March 5.

Shields, K.E. 1978. "Faults Along the Northwestern Margin of the San Fernando Valley, Los Angeles County, California." in Geologic Guide and Engineering Geology Case Histories, Los Angeles Metropolitan Area: Association of Engineering Geologists, First Annual California Section Conference. Los Angeles, California. pp. 44-52.

Sieh, K.E., S. Stuiver, S. Minze, and D. Brillinger. 1989. "A More Precise Chronology of Earthquakes Produced by the San Andreas Fault in Southern California." *Journal of Geophysical Research.* Vol. 94. No. B1. pp. 603-623.

Southern California Earthquake Council and California Institute of Technology Seismological Laboratory. 1994. Written communication.

Teng, T.L. and T.L. Henyey. 1975. "Microearthquake monitoring in the City of Long Beach Area of the Year 1974." University of Southern California Geophysical Laboratory Technical Report 75-2. 50 p.

Tinsley, J.C., T.L. Youd, D.M. Perkins, and A.T.F. Chen. 1985. "Evaluating Liquefaction Potential." In J.I. Ziony (ed.) *Evaluating Earthquake Hazards in the Los Angeles Region - An Earth-Science Perspective*." U.S. Geological Survey Professional Paper 1360.

Tokimatsu, K. and Seed, H.B. (1987). "Evaluation of Settlements in Sand Due to Earthquake Shaking." *Journal of Geotechnical Engineering*. American Society of Civil Engineers. Vol. 113, No.8. pp. 861-878.

URS Corporation. 2001. "Geotechnical Investigation, Proposed Magnolia Power Plant, City of Burbank, California." Consultant's Report for Southern California Public Power Authority. March.

United States Geological Survey Working Group on Earthquake Probabilities. 1988. "Probabilities of Large Earthquakes Occurring in California on the San Andreas Fault." USGS Open File Report 88-398.

Watermaster. 1999. "Watermaster Service in the Upper Los Angeles River Area, Los Angeles County, 1997-98 Water Year, October 1, 1997 – September 30, 1998."

Weber, F.H., J. Bennett, R. Chapman, G. Chase, and R. Saul. 1980. "Earthquake Hazards Associated with the Verdugo-Eagle Rock and Benedict Canyon Fault Zones, Los Angeles

County, California." California Division of Mines and Geology Open File Report 80-10 LA.

Wells, D.L. and K.J. Coppersmith. 1994. "New Empirical Relationships Among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement." *Bulletin of the Seismological Society of America*. Vol. 84. No. 4. pp. 974-1002.

Woodward-Clyde Consultants. 1982. "Evaluation of Geotechnical and Geological Conditions, Fuel Pier Relocation, FY 1984, MCON RE-IMB Project F-384, Naval Station, Long Beach, California." Consultant's Report for Parsons Brinckerhoff Quade and Douglas, Inc. San Francisco, California.

1979. "Report of the Evaluation of Maximum Earthquake and Site Ground Motion Parameters Associated with the Offshore Zone of Deformation, San Onofre Nuclear Generating Station." Consultant's Report for Southern California Edison.

Wright, T.L. 1991. "Structural Geology and Tectonic Evolution of the Los Angeles Basin, California." in *Active Margin Basins*. K.T. Biddle, ed. Memoir 52. American Association of Petroleum Geologists. pp. 35-134.

Yeats, R.S. 1973. "Newport-Inglewood Fault Zone, Los Angeles Basin." *Bulletin of the American Association of Petroleum Geologists*. Vol. 57. pp. 117-135.

Yerkes, R.F. 1985. "Geologic and Seismologic Setting." in *Evaluating Earthquake Hazards in the Los Angeles Region - An Earthquake Science Perspective*. J.L. Ziony, ed. U.S. Geological Survey Professional Paper 1360.

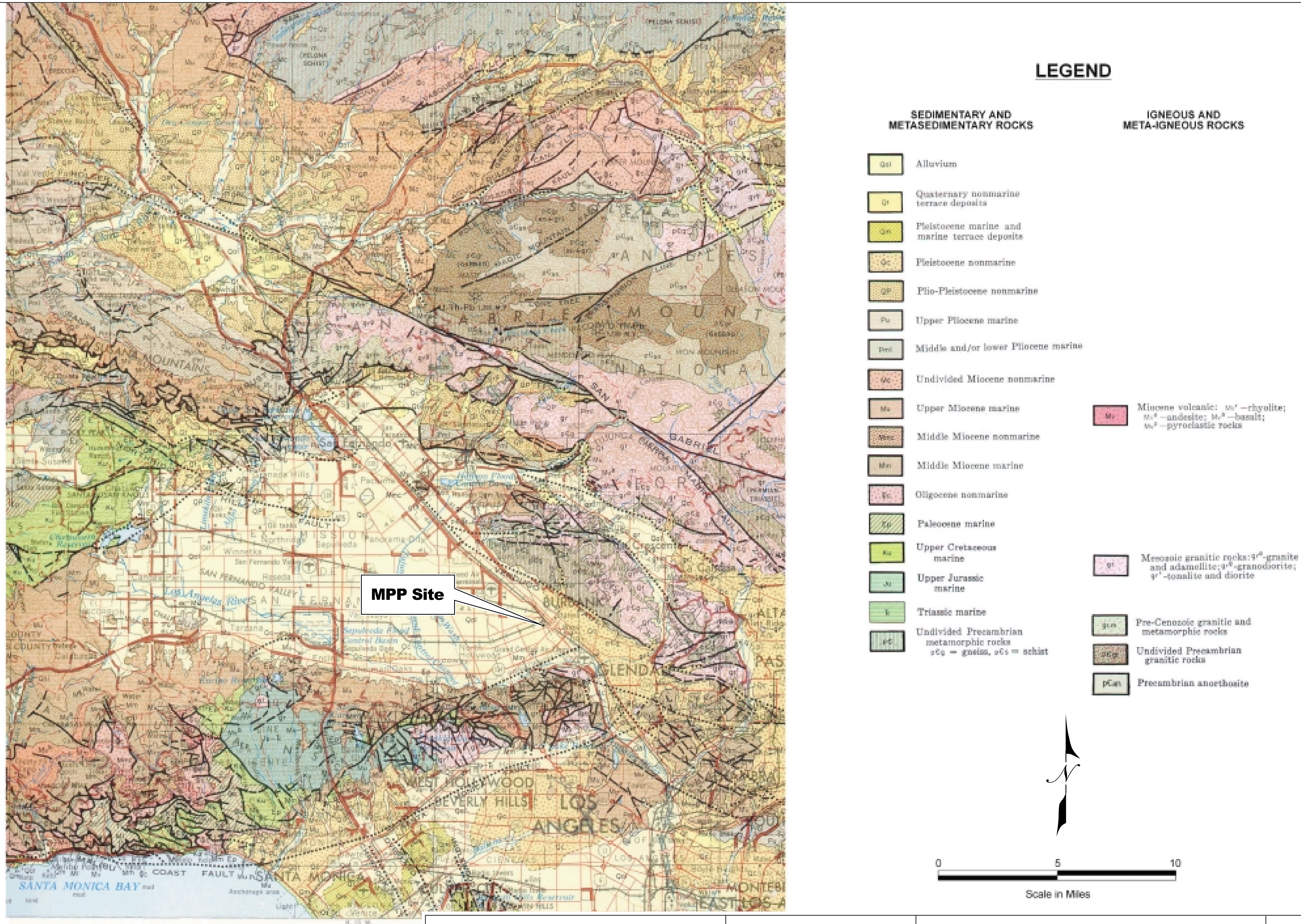
Zielbauer, E.J., H.A. Kues, W.L. Burnham, and A.G. Keene. 1962. "Dominguez Gap Barrier Project Geologic Investigation: Coastal Basins Barrier and Replenishment Investigation, Los Angeles County Flood Control District." No. 33. March.

Ziony, J.I. and R.F. Yerkes. 1985. "Evaluating Earthquake and Surface Faulting Potential." in Evaluating Earthquake Hazards in the Los Angeles Region - An Earthquake Science Perspective. J.L. Ziony, ed. U.S. Geological Survey Professional Paper 1360.

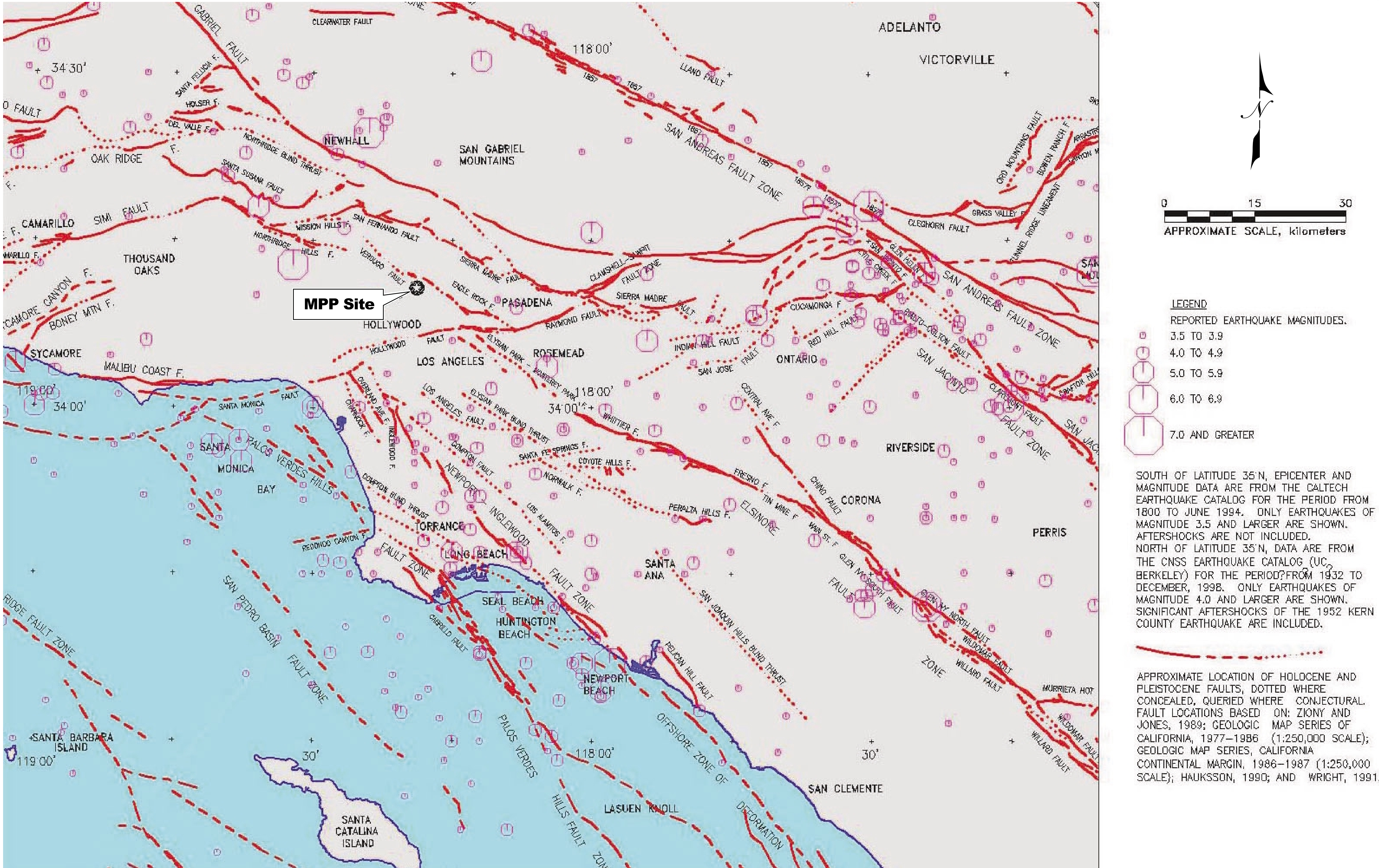
Ziony, J.I., Wentworth, C.M., Buchanon-Banks, J.M., and Wagner, H.C. 1974. "Preliminary Map Showing Recency of Faulting in Coastal Southern California." U.S. Geological Survey Miscellaneous Field Map, MF-585. Map Scale 1:250,000.

Ziony, J.I. and L.M. Jones. 1989. "Map Showing Late Quaternary Faults and 1978-84 Seismicity of the Los Angeles Region, California." U.S. Geological Survey Miscellaneous Field Studies Map MF-1964. Map Scale 1:250,000.

S:\Ladd\BurbankMagnolia\301-075



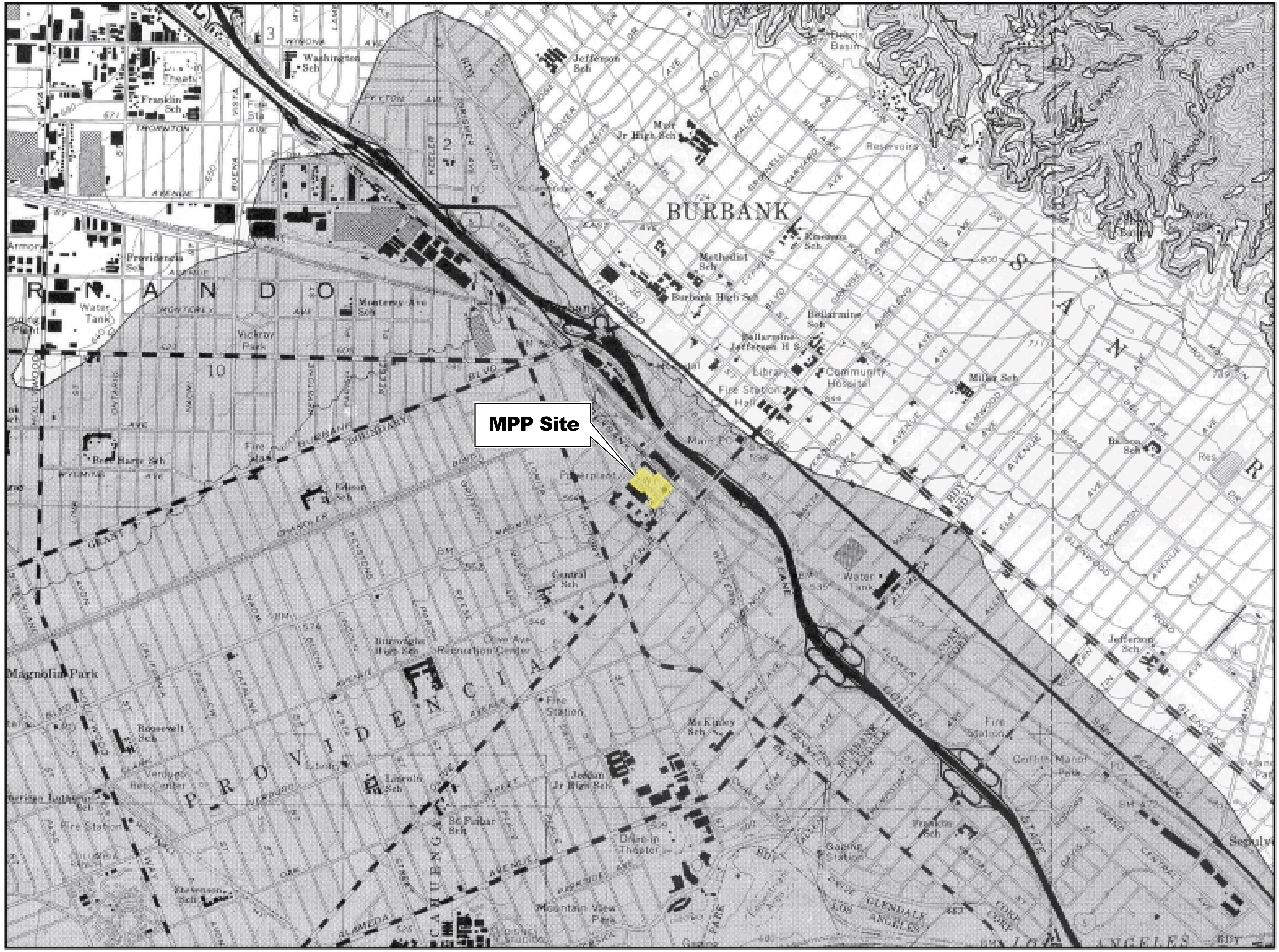
Magnolia Power Project	Source: California Division of Mines and Geology 1969	**Figure 5.3-1.** REGIONAL GEOLOGY	March 2001



L:\Ladd\BurbankMagnolia\301-076

Magnolia Power Project	**Figure 5.3-2.** MAP OF REGIONAL FAULTS AND EPICENTERS	March 2001

L:\Ladd\Burbank\Magnolia\301-074



EXPLANATION

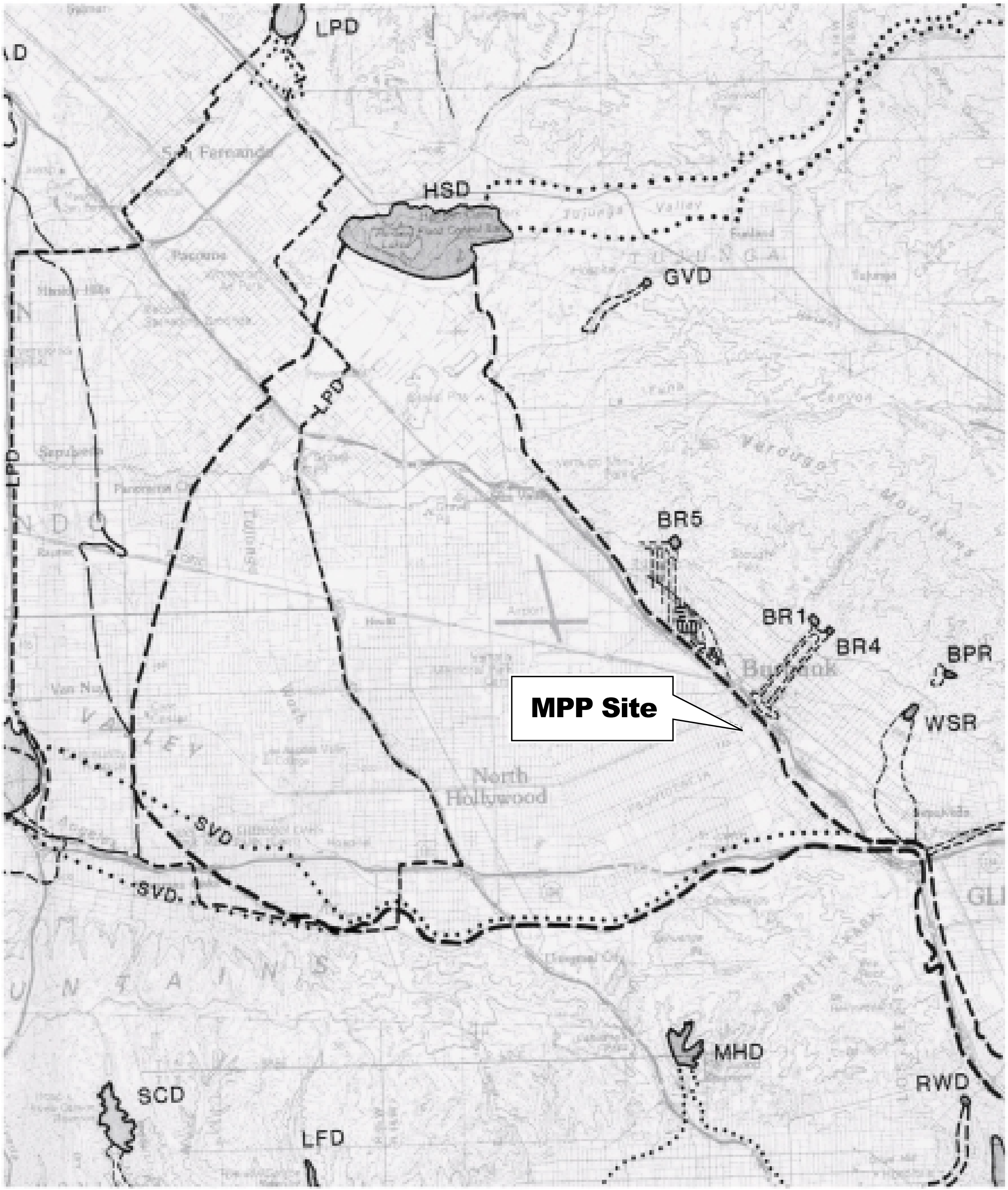
Liquefaction

Areas where historic occurrence of liquefaction, or local geological, geotechnical and groundwater conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

0 2000 4000

Scale in Feet

Magnolia Power Project	**Source:** Basemap taken from Seismic Hazards Zone Map. Burbank, Calif. Quadrangle (Released March 26 1999)	**Figure 5.3-3.** AREAS DEPICTING LIQUEFACTION POTENTIAL	March 2001

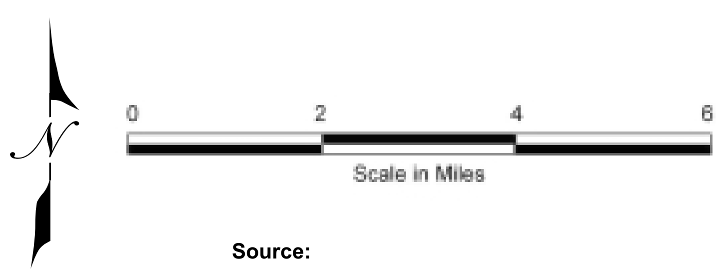


Legend

LOR — Dam of Debris Basin Inundation Area

Dam or Debris Basin Flood Boundaries

HSD - Hansen Dam Inundation Area



Source:
The Flood and Innundation Hazard Map, LA County 1990

Magnolia Power Project	**Figure 5.3-4.** BOUNDARIES DEPICTING AREAS SUBJECT TO DAM FLOOD	March 2001